ECCOMAS
European Community on Computational Methods in Applied Sciences

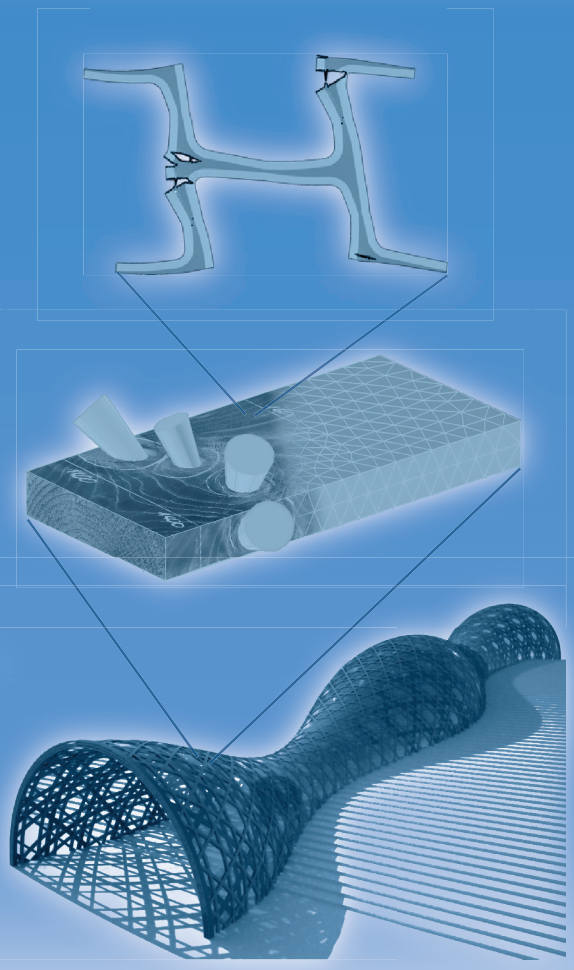
ECCOMAS
Thematic Conference

CompWood 2017

June 7-9, 2017 | Vienna | Austria

Computational Methods in Wood Mechanics – from Material Properties to Timber Structures

Programme & Book of Abstracts



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Prediction of oak wood mechanical properties based on vibratory tests

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Visual grading of timber downgrades wood mechanical properties comparing to machine grading [1]. The most widely recognized grading machines are based on resonance frequency measured from vibratory tests. The prediction of the modulus of elasticity (MOE) can be accurately determined with these vibratory methods [2]. However it is more difficult to predict the modulus of rupture (MOR) especially in the case of low correlation between MOE and MOR. Indeed, this work concerns low grades of French oak for which the coefficient of determination between MOE and MOR equals 0.4.

The present paper presents a deeper exploitation of output parameters of vibratory tests in the aim of a better prediction of the MOR. To achieve that, two statistical methods are introduced.

The first one is Partial Least Squares (PLS) for which each amplitude of the spectrum is considered as a predictive variable. The same method has been used before for larch species [3] but in this latter work the predictions of MOE and MOR depended on board's section and percussion impact. In the present study, these effects have been removed thanks to a normalization of the signal.

The second method relies on global output parameters of vibratory tests (Young modulus, shear modulus, density..etc) totaling 31 parameters. A stepwise regression is applied to reveal the most correlated parameters to observations (MOE or MOR).

For a set of 150 oak boards with different sections, the efficiency of models is evaluated through the coefficient of determination between the predictive values and values obtained thanks to four points bending tests (MOE and MOR). To estimate the stability of models, a cross validation technique is used and consists in partitioning the original sample into a calibrating set to set the model, and a validating set to evaluate it. At the end, the root mean square of cross validation (RMSECV) is calculated. Table 1 shows a comparison of the two proposed methods and the usual one.

	MOE		MOR	
Variable or method of prediction	**R^2**	**RMSECV (MPa)**	**R^2**	**RMSECV (MPa)**
Acoustic compression MOE from first Eigen frequency	0,76	1109	0,27	19,3
PLS based on full vibrational spectrum	0,64	1553	0,63	17,3
Stepwise regression based on Eigen frequencies	0,86	883	0,46	17,2

Table 1 : Main results of MOE and MOR prediction

Stepwise technique significantly improves the prediction of MOE and reduces the error of prediction comparing to a compression vibratory test based only on the first Eigen frequency. PLS allow to enhance the coefficient of determination of the MOR from 0.27 to 0.63. However, it is difficult to make a difference between PLS and stepwise methods because their RMSECV are close: both are reduced by 2 MPa compared to a usual vibratory test based only on the first Eigen frequency. These results are being confirmed by a large experimental campaign including 450 boards of French oak. They show that a deeper exploitation of vibratory signals can lead to a better wood grading.

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